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| Last Name | First Name, MI | INVENTOR(s)/APPLICANT(s) Residence (City and Either State or Foreign Country) |
|-----------|----------------|--|
| Aubrey | Leonard, S. | Hendersonville, NC |

TITLE OF THE INVENTION

COMPACT MICRO-POROUS MÉDIA DEGASSER

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ENCLOSED APPLICATION PARTS (check all that apply)

- (X) Specification
 (X) Drawing(s)
 () Power of Attorney

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METHOD OF PAYMENT

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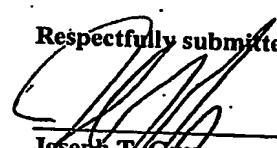
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Respectfully submitted,


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Compact Micro-porous Degass r-Filter System

Background

This memorandum of invention is a continuation of the memorandum of invention submitted on June 3, 2003 titled *Memorandum of Invention Covering Micro-Porous Degasser*. This MOI extends the previous MOI by detailing the physical design of a compact in-line micro-porous degasser combined with filtration.

Refinement of molten aluminum requires both degassing to remove soluble hydrogen and filtration to remove insoluble liquid (salts) and solid (oxides, borides, spinels) inclusion material.

Historically metal treatment systems in aluminum cast houses have utilizing spinning rotors to generate small gas bubbles to remove hydrogen followed by filtration utilizing either a deep bed filter or a ceramic foam filter. These systems generally occupied a significant amount of floor space in an aluminum cast house and require that molten metal be held between casts in one or both treatment units. Figure 1 shows a typical in-line spinning rotor degasser. The design of these types of degassers requires that molten metal be held between casts. This has two operational drawbacks. One is that external heat source must be used to keep the aluminum molten between casts. This requires an elaborate heating system (capital expensive) and attendant energy consumption (consumable expense). The second draw back is that in order to change the alloy composition, the treatment unit must be drained and refilled with the correct aluminum alloy (labor, conversion cost). A more compact degasser has recently been developed by Alcan and sold by STAS Ltée.¹ This system, shown in Figure 2, while fully drainable between casts, is hardy compact. It requires a significant amount of floor support for the launder and ancillary support equipment (degassing hood, baffle plates, drive modules including rotors, lifting mechanism, fume exhaust system, PLC panel and interface and gas mixing panel).

Filtration is usually carried out immediately downstream or after the in-line degassing system. Filtration is carried out using either a deep bed filter or a ceramic foam filter. A deep bed filter typically is a very large refractory box containing tabular alumina as the filter media. Figure 3 shows a typical bed filter used in a cast house. Bed filters hold molten aluminum between casts and therefore require an external source to keep the metal molten. Alloy changes are therefore very expensive and result in significant production downtime. Typical size of a bed filter for a 1,000 pound per minute flow rate is 80" wide X 106 long X 50" high. Figure 4 shows a ceramic foam filtration system, which compared to a deep bed filter, is significantly smaller. Typical foot print size for a ceramic filtration is 40" wide X 40" long X 48" X 30" high. A ceramic foam filtration system key advantage is that the molten metal is drained from the system after the completion of each cast. This eliminates the need for an external heat source and provides complete operational flexibility.

Compact Micro-Porous Degasser-Filtration System

Figures 5 through and 13 contain schematic illustrations of the micro-porous degasser-filtration system. The key components of the system are:

1. **Micro-porous Degassing Plate:** The micro-porous plate contains an array of holes that the molten metal flows downwards through. Attached to the micro-porous plate is a nonporous tube through which an external vacuum is applied to the micro-porous plate.

Ceramic Foam Filter: Situated immediately below the micro-porous degassing plate is a foam filter plate. The ceramic foam filter plate is comprised of one or more pore size layers. Between the micro-porous plate and ceramic foam filter element is a gap (0.25" to 2") to promote uniform metal flow into the ceramic foam filter plate.

3. **Refractory Containment Vessel:** The micro-porous degasser plate and ceramic foam filter element are contained in a refractory monolithic capable of withstanding contact with molten aluminum. The purpose of the vessel is to mechanically retain the micro-porous degassing plate and ceramic foam filter element. Typically the refractory contact material would be a fused silica shape placed supported by an outside steel shell. The key features are 1) inlet, 2) a substantially horizontal seating surface for the micro-porous plate, 3) a substantially horizontal seating surface for the ceramic foam filter element, 4) sloping bottom surface to promote draining, outlet tunnel to re-direct the metal upwards to the reconnecting launder.
4. **Preheat Burner System:** The function of the preheat burner is preheat both the micro-porous degassing plate to promote priming. The burner is placed into the outlet tunnel to preheat both the degassing and filter plates. Prior to the start of casting the preheat burner is removed.
5. **Drain System:** A removal drain plug or mechanism is contained in the outlet section to allow the system to be fully drain between casts. The bottom of the system is sloped towards the outward to promote draining.

Figure 5 schematically illustrates the compact micro-porous degasser-filter system in operation. Molten metal enters the system and flows downward through the holes in the micro-porous degassing plate. Hydrogen is removed by reaction of dissolved hydrogen gas at the metal/micro-porous plate interface:



The hydrogen gas is then removed by the vacuum, which is applied through a nonporous tube attached to the micro-porous plate. The purpose of the holes in the micro-porous plate is to:

1. Reduce the required diffusion path (distance) for the dissolved hydrogen to reduce the removal interface.
2. Increase the contact surface area for hydrogen removal.

The holes shown in the illustrations are $\frac{1}{4}''\varnothing$ on $3/8''$ centers in a close packed array. The plate thickness is 4". Hole size (diameter) could range from as small as 500 microns to as large as 50 mm, but optimum hole spacing is likely between 3 mm and 10 mm. Plate thickness could range from 3 mm to 200 mm. Hole spacing would be from $\frac{1}{2}$ to 10 times the hole diameter. Spacing pattern or configuration could be simple orthogonal or close packed arrays. Possible materials for the construction of the micro-porous plate are contained in the first memorandum of invention.

The molten metal flows downwards through the ceramic foam flow filter where insoluble inclusions (solid and liquid) are removed. The metal then exits the filter and flows upwards into the casting launder. The bottom of the refractory vessel contains a downward slope towards the outlet/drain hole. At the completion of casting the drain plug is removed and the system is allowed to drain.

In preparation for the next cast the drain plug is inserted. A gas preheat burner is placed into the outlet (Figures 7 – 9). The purpose of the burner is to preheat the entire system in preparation for the next cast. Immediately prior to the start of the cast the burner is turned off and removed. The preferred type of burner is a medium velocity burner with excess air capability. This type of burner using around 100% excess air preheats both the micro-porous degassing plate and the ceramic foam filter element by convective heat transfer.

Possible System Permutations

1. The system is operated without the ceramic foam filter plate (degassing mode only).
2. The micro-porous plate is installed in a vertical orientation at the inlet side
3. The system is not drained between casts. An external heat source is utilized to keep the metal molten between subsequent casts.
4. The positions of the ceramic foam filter and micro-porous degassing plate are reversed.
5. More than one stage of filtration is employed (two-stage filtration).

References

1. P.D. Waite, "Improved Metallurgical Understand of the Alcan Compact Degasser after Two Years of Industrial Implementation in Aluminum Casting Plants", Conference Proceedings at the 127th TMS/AIME Annual Meeting, San Antonio, Feb. 1998, pages 791-796

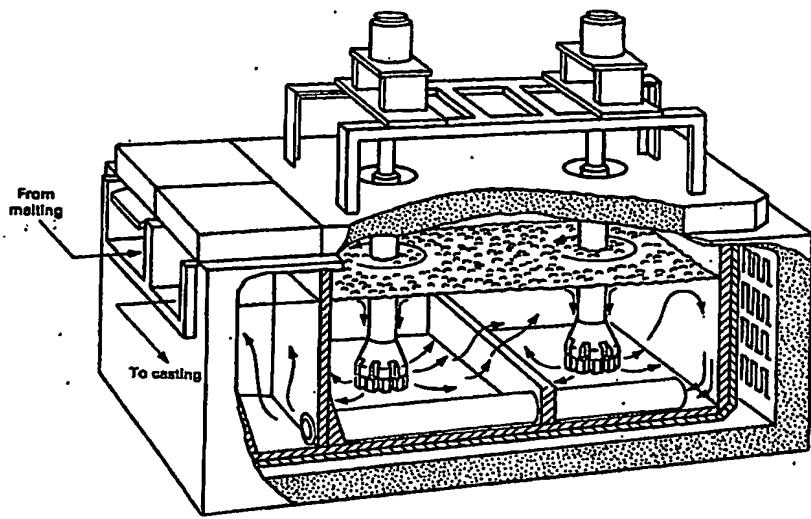


Figure 1: Schematic illustration of a SNIF in-line rotary impeller degasser where an inert purging gas is used to remove soluble hydrogen from molten aluminum. Typical size of box is 6' wide X 6' high X 10' long.

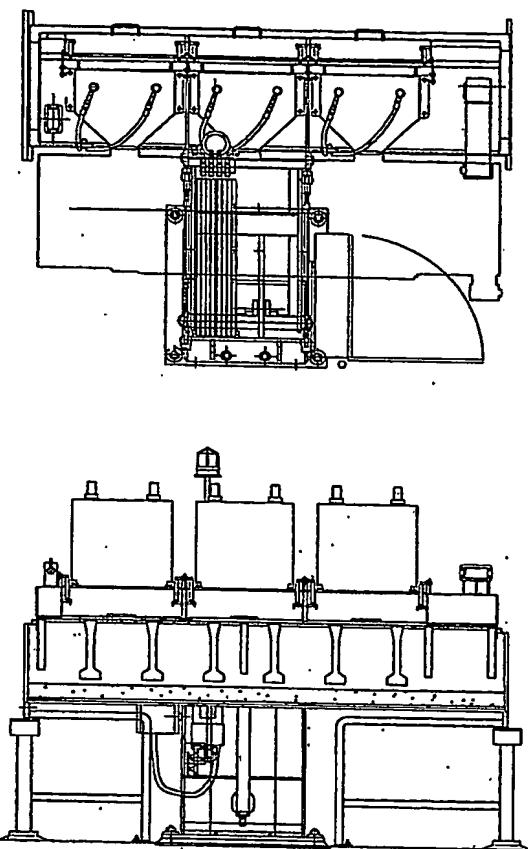


Figure 2: Schematic illustration of an Alcan compact degasser (ACD). The overall physical dimension of an ACD is about 118" L X 96" H X 85" W. This does not include ancillary support equipment such as gas mixing panel

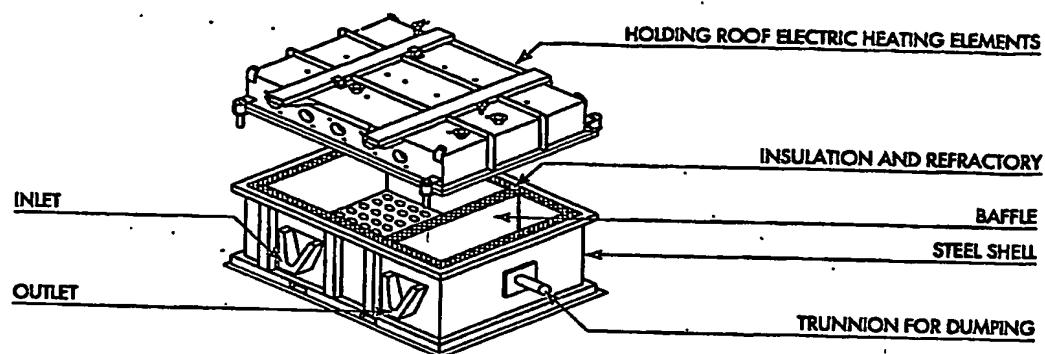


Figure 3: Schematic illustration of a deep bed filter system.

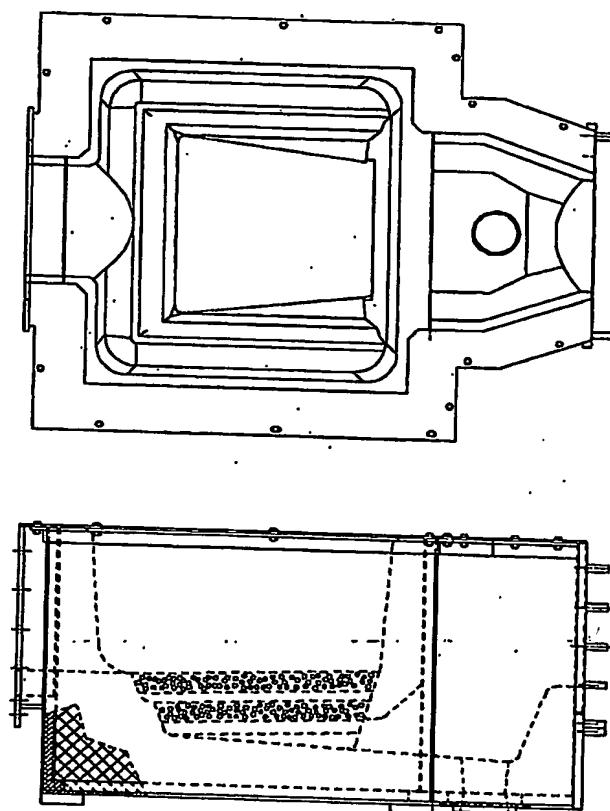


Figure 4: Typical two-stage ceramic foam filter system.

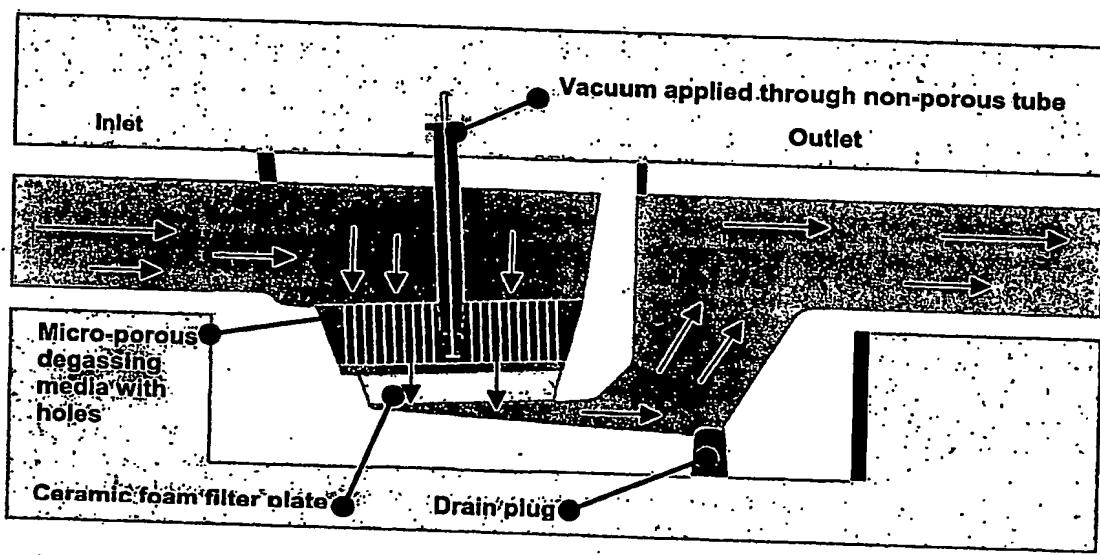


Figure 5: Schematic side view illustration of the compact micro-porous degasser filter apparatus. Black arrows signify the metal flow direction.

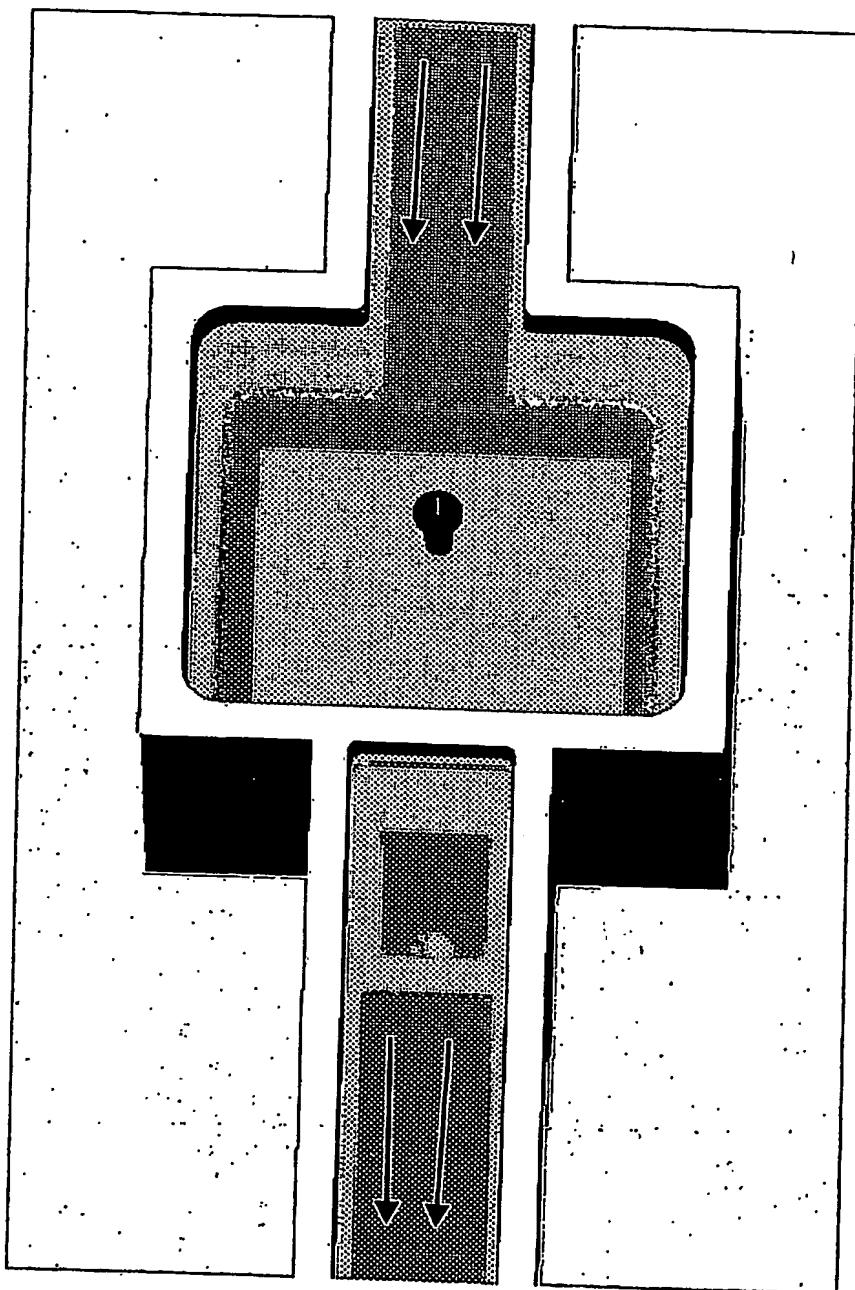


Figure 6: Semi-transparent schematic illustration of compact micro-porous degasser filter apparatus. Black arrows signify the metal flow direction.

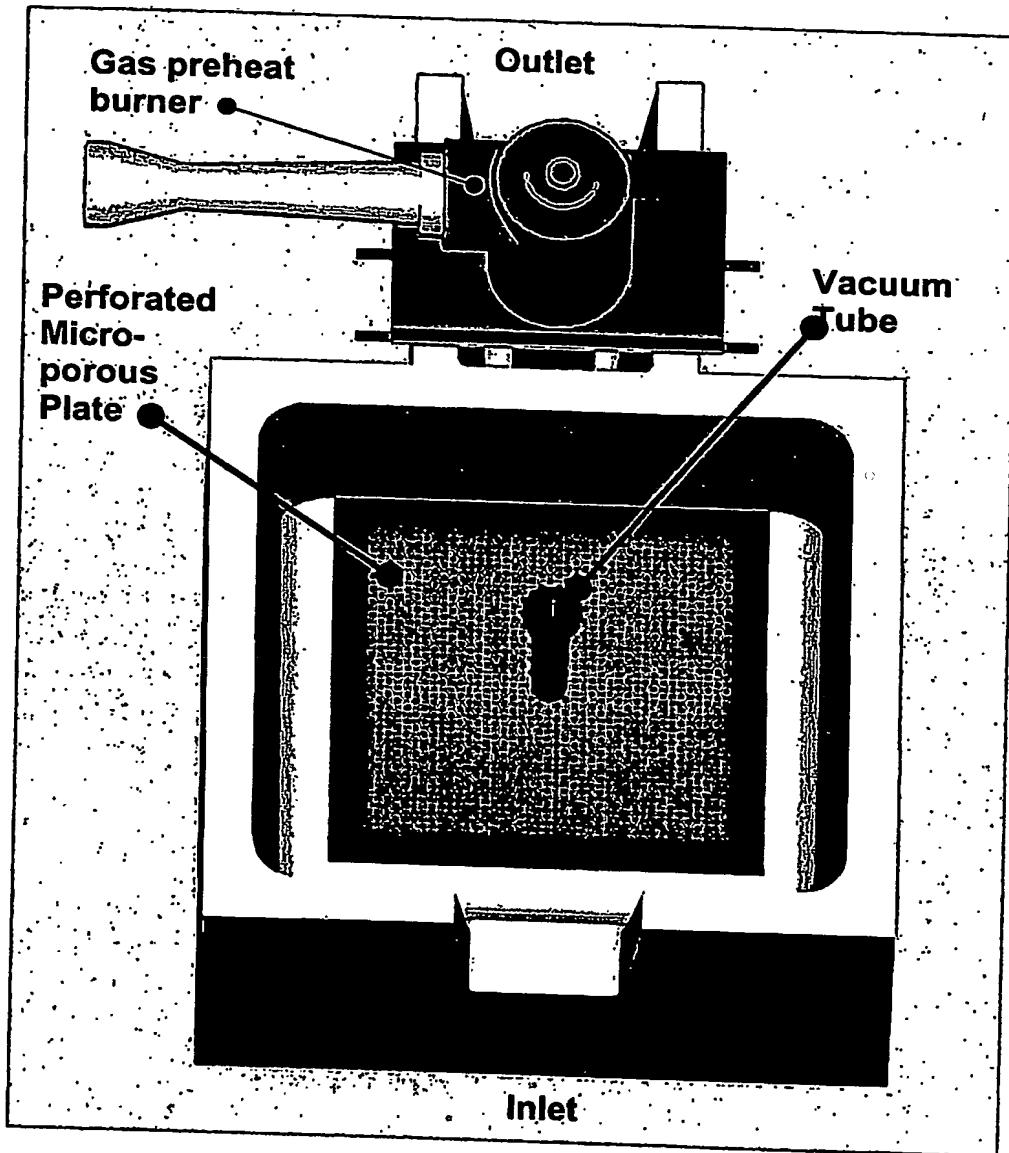


Figure 7: Schematic illustration of compact micro-porous media degasser-filter showing a perforated micro-porous plate (red), non-porous vacuum tube (blue) and the media velocity (excessive air) gas preheat burner (green).

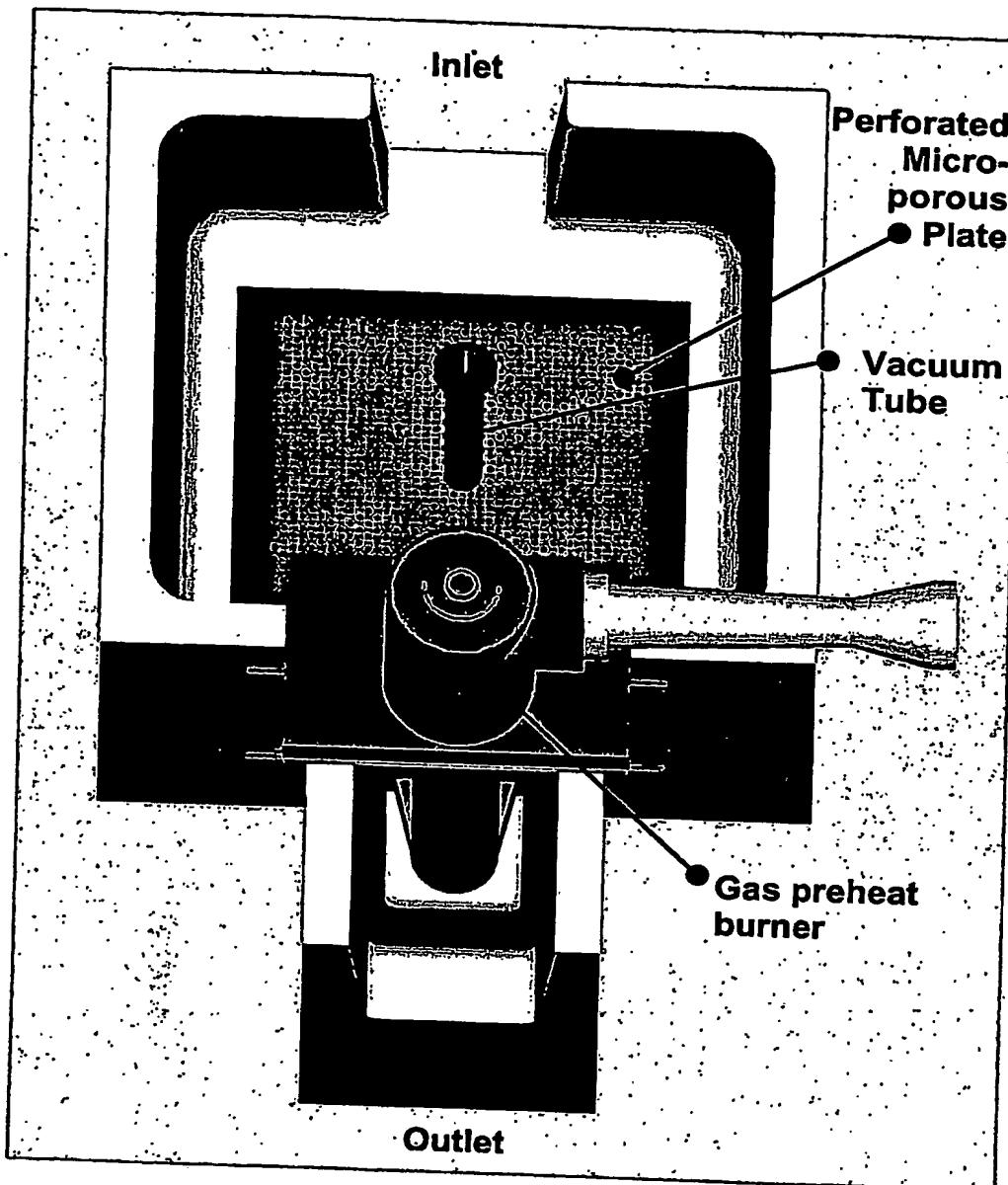


Figure 8: Schematic illustration of compact micro-porous media degasser-filter showing a (excessive air) gas preheat burner (green).

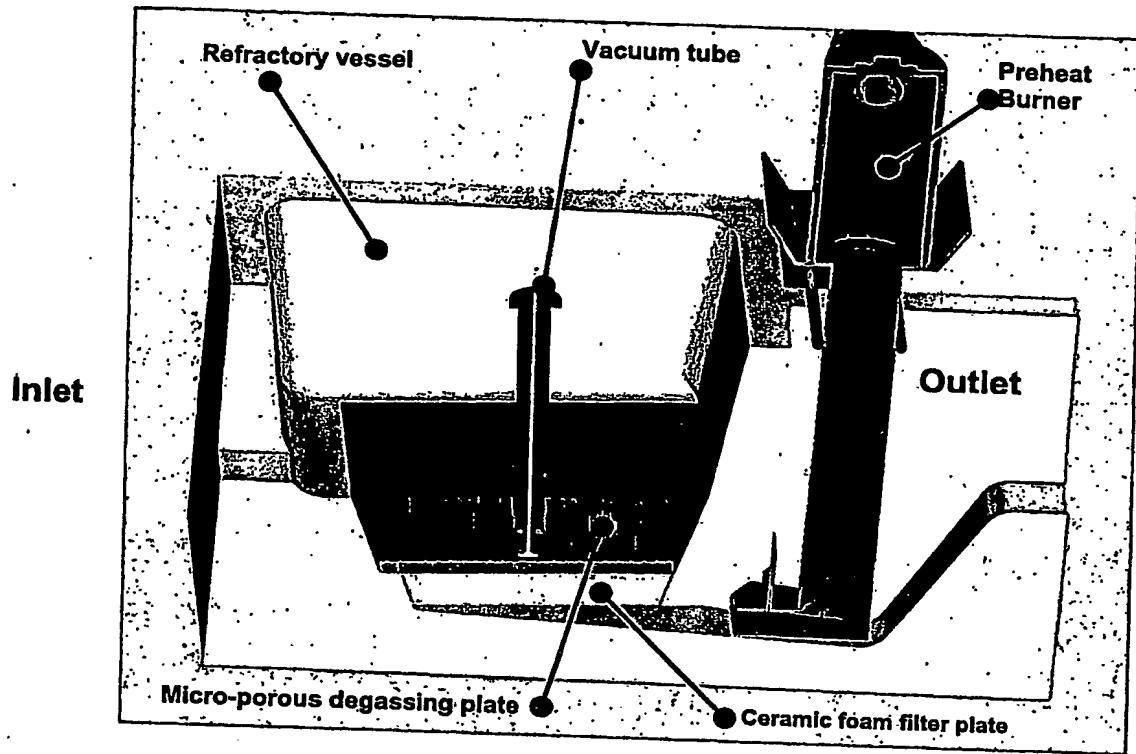


Figure 9: Sectional view of compact micro-porous degasser-filter showing a perforated micro-porous plate (red) and ceramic foam filter element (beige). The molten metal enters the treatment vessel from the left side and passes through the vertical channels or holes in the micro-porous plate where hydrogen is removed. A vacuum is applied to the perforated micro-porous plate through the connecting vacuum tube, which removes hydrogen gases that diffuse into the plate. The molten metal then passes down through a ceramic foam filter element where insoluble liquid and solid inclusions are removed. The metal then exits upwards through the outlet tunnel and into the casting launder. A preheat burner is provided to preheat the filter prior to the start of casting. Note: Drain plug not shown.

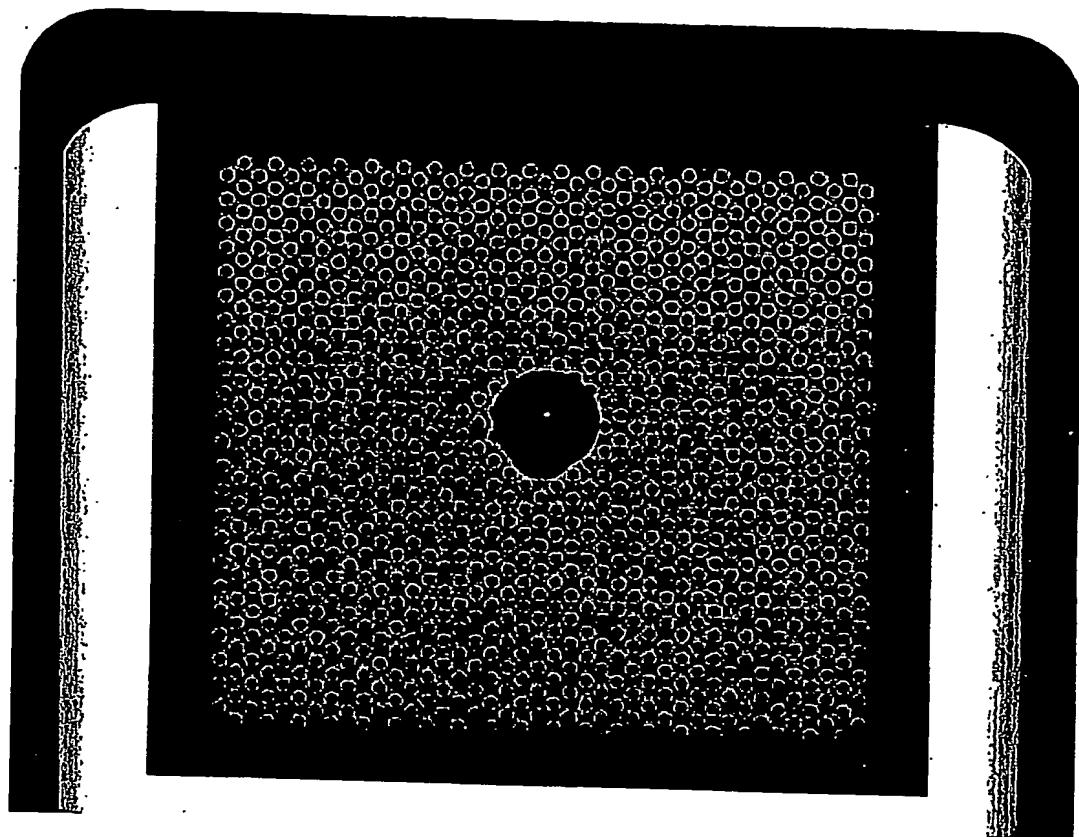


Figure 10: Hole configuration in micro-porous degassing plate.

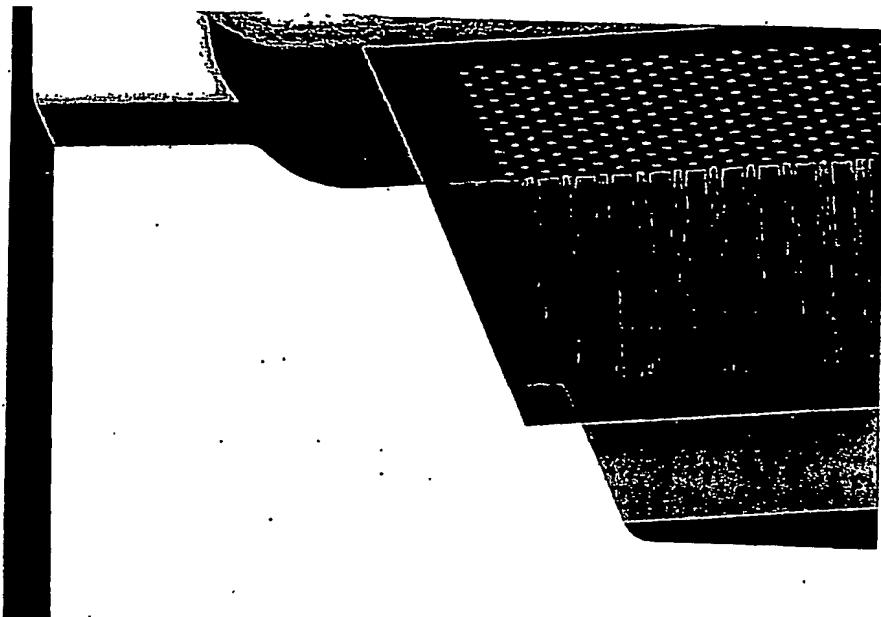


Figure 11: Details of installation of micro-porous degasser plate (red) and ceramic foam filter element (beige). Vertical gap is a critical detail.

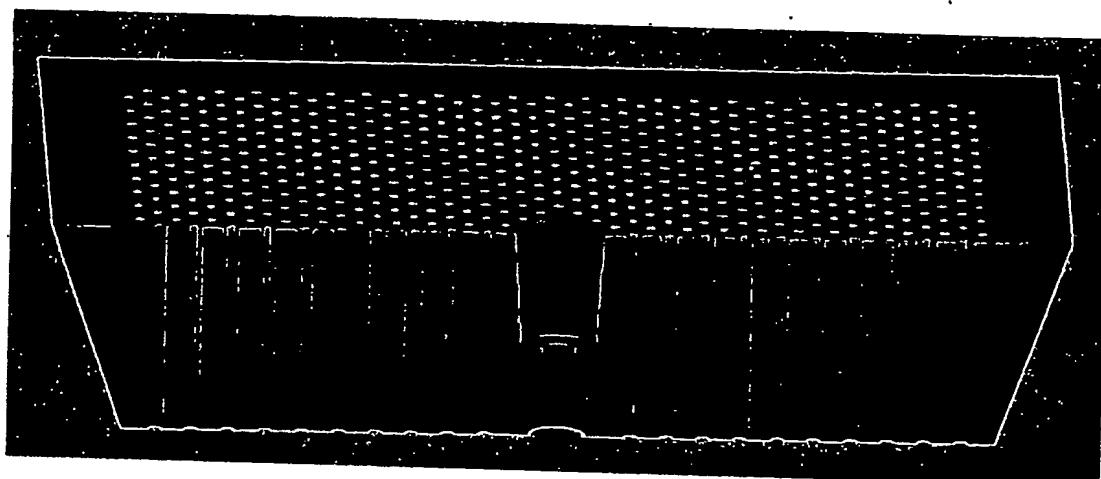


Figure 12: Cross section of micro-porous degassing plate

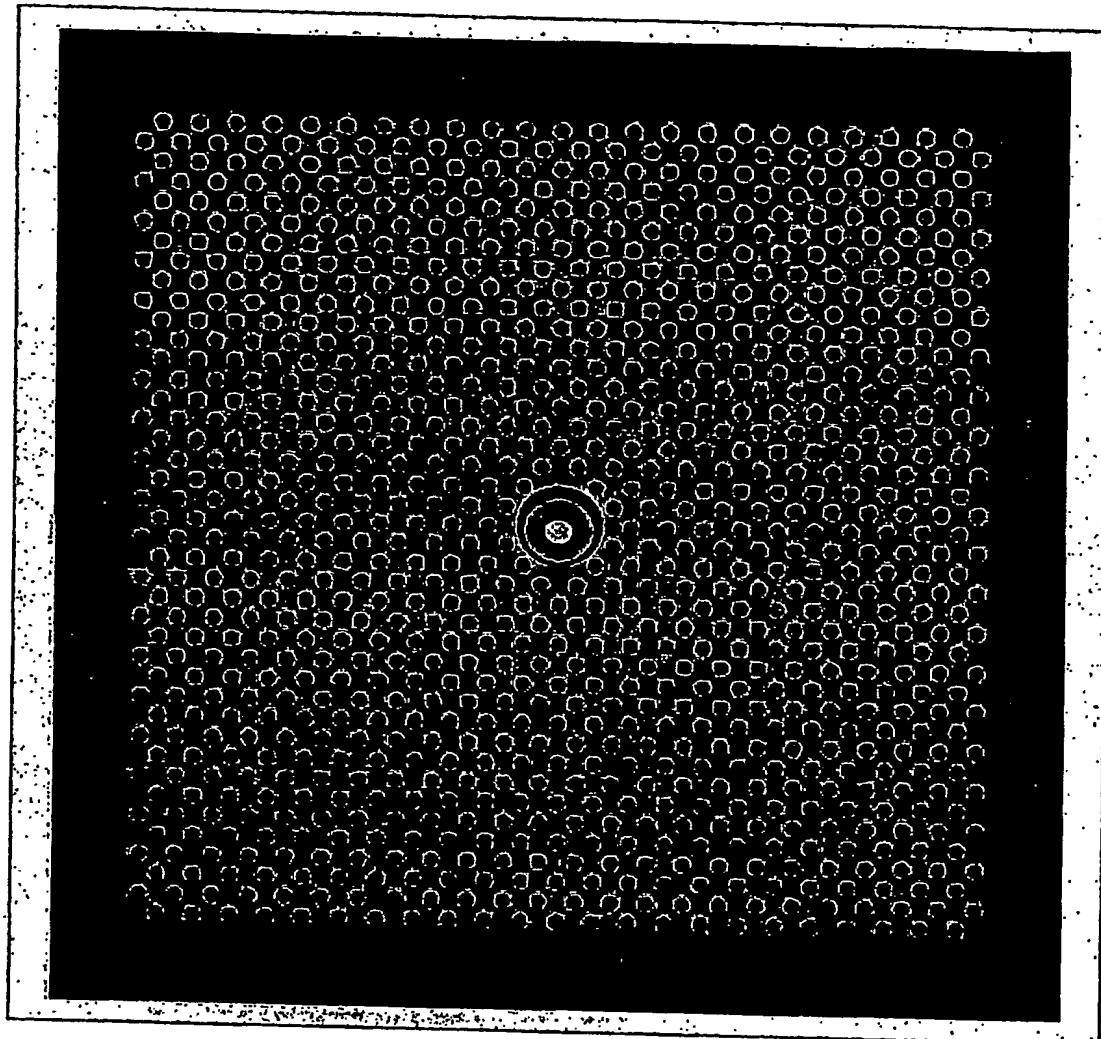


Figure 13: Inlet side of micro-porous degassing plate.

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